

learning, but with particular grace we encourage philosophical studies, especially those which by actual experiment attempt either to shape out a new philosophy or to perfect the old. In order, therefore, that such studies, which have not hitherto been sufficiently brilliant in any part of the world, may shine conspicuously amongst our people, and that at length the whole world of letters may always recognise us not only as the Defender of the Faith, but also as the universal lover and patron of every kind of truth: Know ye, &c.

Of the "Fellows" we read later on :—

The more eminently they are distinguished for the study of every kind of learning and good letters, the more ardently they desire to promote the honour, studies, and advantage of this Society . . . the more we wish them to be especially deemed fitting and worthy of being admitted into the number of the Fellows of the same Society.

"Every kind of learning and good letters" seems to me pretty general, and it does not seem improper to take the words "philosophical studies," in connection with Bacon's definition of philosophy, as dealing with a three-fold division, of matters divine (supernatural), natural, and human, which also, perhaps, explains the subsequent insistence upon natural, as opposed to supernatural, knowledge.

But, without labouring this point further, I suggest that subjects the study of which by scientific methods increases the sum of natural knowledge must all stand on the same footing. I use the word "scientific" in its widest, which I believe to be the truest, sense, as including all additions to natural knowledge got by investigation. Human history and development are as important to mankind as the history and development of fishes. The Royal Society now practically neglects the one and encourages the other.

It is possible, then, to say the least, that the present general action of the society, and I say general, because the action changes from time to time, is really not in accordance with its charters; it certainly is not with its first practice. The charters make the society the head centre of the intellect of the kingdom engaged in making new natural knowledge, and therefore until these charters of King Charles II. are abrogated or revised there is no place logically for a new charter by King Edward VII. giving power to a new body to deal with the subjects the duty of the organisation and encouragement of which was previously committed to the Royal Society.

There can be no question that the gradual departure of the action of the Royal Society from the course laid down in the charters, and actually followed for a time, has been the gradual expansion and increased importance of experimental and observational methods of work, which of themselves are sufficient to employ the existing administrative machinery. But, if the whole work cannot be done inside the society as it exists at present, the question arises, Cannot some be organised side by side with it? Here, again, there may be difficulties; but, as the committee wisely say with regard to the first proposal :—

We are far from intending to express an opinion that any difficulties of detail ought to prevent the important issues involved from being fully considered in their largest bearings, having regard to the great benefits which might be expected to result to the progress of the philosophico-historical studies, and possibly to the Royal Society itself, from the inclusion of those studies within the scope of the society's action.

It is right that I should say that the Royal Society Council, in the resolution from which I have already quoted, expresses sympathy with the desire to secure a proper representation of the subjects now in question, and did not refuse to include them within itself, although its action may give colour to the belief in such an effect.

At present the Royal Society is the unique recognised centre of the general scientific activity in this country.

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Will it be conducive to the interests of science, or even of the Royal Society itself, that in future there should be two entirely separate centres?

But will not this state of things be brought about if, without any general consideration, a charter is at once granted to the new body?

The important thing to secure is that the two bodies dealing with the two great groups of scientific subjects shall form part of one organisation—some enlarged Royal Society. What the *nexus* shall be is a matter of such subordinate importance that I do not propose now to refer to it further.

May not this present difficulty, Sir, be really a blessing in disguise? Does it not merely emphasise the activity of the scientific spirit and the employment of the scientific method in new regions, and suggest that the time has arrived, at the beginning of a new century and a new reign, for doing for the science of to-day what Charles II. did for the science of the seventeenth century—that is, organising and coordinating it on a broad basis?

It is clear that the question so wisely referred by His Majesty Edward VII. to the Privy Council is no light one, for the acts of a previous King of England and the future development of British science are involved. The present confusion is great and will become greater if a new charter is granted without a comparison and possible revision of the existing ones; and, short of an inquiry, by a Royal Commission or by some other means, to consider the question, it is difficult to see how the proper organisation of natural knowledge in the future can be secured.

It is fortunate that there is ample time for this important matter to be considered carefully in all its bearings, for not till 1904 can any British representation of the philosophico-historical subjects be considered by the International Association of Academies.

May I finally be permitted to say, Sir, how entirely I agree with the remarks in the leading article in the *Times* of the 16th inst. concerning the importance of organising literature as well as science? Science has undoubtedly gained by the charters of Charles II., and on this ground alone it may be urged that literature will be a gainer if it also is similarly organised. Certainly the most impressive sight I saw in Paris last year, when attending the first meeting of the International Association of Academies as a Royal Society delegate, was the reception of a new literary member of the Académie Française. The combination of troops representing the Government and members of other academies representing the Institute of France formed a picture which is not easily forgotten; it was one also to set one thinking.

I am, Sir, your obedient servant,

NORMAN LOCKYER.

THE EIFFEL TOWER.

La Tour Eiffel en 1900. Par M. G. Eiffel, Officier de la Légion d'Honneur. Pp. 363. (Paris: Masson and Co., 1902.)

IN a handsome volume, profusely illustrated with engravings and photographs, M. Eiffel has given an elaborate account, from its earliest conception, of the lofty structure that will always bear his name, and of the mechanical devices which have secured its success, both as a worthy monument of the art of construction and as a source of delight to the millions who have ascended it. We understand and regret that this monograph in some measure owes its appearance to the attacks of detractors, and it is intended to furnish a complete answer to those who, disapproving of the structure, have commented on its puerility and its uselessness. This ill will, well pronounced in the early days of the structure, and to which

M. Eiffel refers at length, has possibly revived since the falling off of receipts on the occasion of the last exhibition, and the well-earned reputation of the author may have suffered in consequence. Certainly no less than three descriptions of the Tower have emanated from the eminent engineer in a short space of time. The first, entitled "*La Tour de trois cents Mètres*," was an *ouvrage de luxe*, a massive folio volume with sixty-seven plates, also in folio. This work, intended for experts, has been presented to various public libraries and scientific societies, and will be consulted with interest by those engaged in similar projects of construction. Next appeared, in a more handy form, "*Travaux Scientifiques exécutés à la Tour de trois cents Mètres*," which, though not generally circulated, was intended to form a complete refutation to those who still urged the plea of inutility against the structure. The present volume appears to follow a middle course between these two, the author giving an account of the history of the construction of the Tower, the modifications that were suggested, after the experience gained in 1889, to make it more accessible to visitors in 1900, together with some account of the scientific investigations which this unique structure rendered possible or facilitated by reason of its height and form.

We have here, therefore, a complete history of the building from the date of its proposal in 1886 up to the present time, and of necessity many of the details have already appeared in the public journals, while the authors of the scientific work that has been carried on in connection with it, having contributed their results to various scientific bodies, have had them published in due course, and these have been commented on in our columns from time to time. As an example, one may refer to M. Janssen's researches on the telluric origin of the lines of oxygen in the solar spectrum, which were carried out in 1889. The value of the book consists in the completeness of the historical details and the ready access it offers to much that has been accomplished in connection with the Tower, particularly in the way of meteorological observations. M. Eiffel naturally thinks it a complete answer to his detractors, but whether this be so or not, it is impossible not to recognise that the management has welcomed with loyalty and assistance every scientific project that has been recommended to its consideration. One gathers that in the view of the promoters, the Tower was never intended to be either a scientific laboratory or a judicious pecuniary investment. We may quote here M. Eiffel himself:—

"Il me semble que, n'eût elle pas d'autre raison d'être que de montrer que nous ne sommes pas simplement le pays des amuseurs, mais aussi celui des ingénieurs et des constructeurs qu'on appelle de toutes les régions du monde pour édifier les ponts, les viaducs, les gares et les grands monuments de l'industrie moderne, la Tour Eiffel mériterait d'être traitée avec considération."

And again:—

"Étant la plus saisissante manifestation de l'art des constructions métalliques par lesquelles nos ingénieurs se sont illustrés en Europe, elle est une des formes les plus frappantes de notre génie national moderne."

Looked at from this point of view, its existence is its justification. It accomplished what was demanded of it,

and its scientific applications, useful as some of them may be, are no more than an ornamental fringe to the main design.

In 1889 nearly two million visitors paid for admission or ascent, and the lifting apparatus had been taxed to the extent of carrying 23,000 persons in a day. With the view of offering greater accommodation on the occasion of the exhibition in 1900, when as great or greater numbers of visitors might be expected, it was determined to increase the accommodation on the various platforms and to rearrange the mechanism of the lifts so that a greater number of ascents could be made per hour. The alterations, necessarily of a costly character, are described in very great detail, and when completed provided for the partial or complete ascent of 3120 passengers per hour, instead of 2680 per hour, as in 1889. Or regarded from another point of view, while the total receipts under the old system could not exceed 5240 francs per hour, under the new arrangement, with a lower tariff, the hourly receipts could amount to 7120 francs per hour. A great deal of work had to be effected, and the manner of its accomplishment, interesting to experts, will be found set out with great clearness and precision. How the sanguine expectations were disappointed is a matter of history, and the falling off in the number of visitors to about one-half is to be regretted; but the efficiency of the arrangements and the success with which they worked should be a matter of congratulation from an engineering point of view.

Having disposed of these mechanical arrangements, to which are added some interesting statistics connected with the financial side of the question, M. Eiffel gives some account of the various scientific purposes to which the Tower has been put during the last eleven years. These, referring to meteorology, to atmospheric electricity, to the construction of a manometer for high pressures, and a variety of other researches, have been mentioned in these columns at the time the different physicists engaged in the work published the results of their investigation. Although mention has already been made of wind observations in connection with the Tower, notably in vol. xlix. p. 596, and li. p. 181, we are tempted to return to this question and give the results of a simple investigation conducted by M. Eiffel to detect the amount of motion that the structure experienced under the influence of a high wind. It will be remembered that the opponents to the scheme of construction in the early days made a strong point of the difficulties that would ensue from excessive wind pressure, and the point is interesting, not only on that account, but because a great deal of loose information is current concerning the motion of tall chimneys and steeples. Anemometry, when applied to considerable areas, is not in a very satisfactory condition, and the necessary strength to be given to buildings is more or less a matter of conjecture and experience. M. Eiffel's method of observation was exceedingly simple. On the third platform, at a height of 309 m., was placed a diagram of concentric circles alternately coloured white and red, each 20 mm. in breadth, and ten in number. The centre of this target, if it may be so described, was made to coincide with the intersection of the cross wires of a solidly mounted theodolite at the base of the eastern pillar. It seems to have been assumed that the telescope

would not move, and the observation was effected by noticing the circle on the diagram which came under the intersection of the cross wires. It is not very clear how the motion in the line of sight was measured, or how the effects of foreshortening were removed. There was no illumination, and the observations were confined to daylight. The general effect of the wind is to make the top of the Tower describe an ellipse, and several diagrams are reproduced showing the effect of the greatest storms. The maximum displacement occurred during the storm of December 20, 1893, when the major axis of the ellipse was 0.10 m., and the minor axis 0.06 m. The time occupied in the description of the ellipse would have been interesting, but is not given. The measured velocity of the wind at the moment of observation is recorded as 31.8 m. per second, or 71 miles per hour. During this storm a velocity of 44 m. per second, or 98 miles per hour, was recorded, but at that moment the major axis of the ellipse was only 0.06 m. This seems to have occasioned M. Eiffel some surprise, but fortunately these excessive gusts are generally operative over a very small area, and the total wind force on the Tower is not to be measured by that experienced at a point very near the anemometer. The same apparatus has served for the measurement of the effects of temperature. The curves traced are generally of a complex character, depending on the position of the sun, and consist mainly of small excursions into the north-west and west quadrants. An example is given of the motion on a very hot day in August, when the centre of the diagram practically traced an elongated ellipse, 24 cm. in length, parallel to the east and west direction.

The researches summarised in the volume appear to be rather unequal in value, and a very small connection with the Tower affords a sufficient warranty for their introduction. Thus we get some account of the recent balloon ascent of M. Santos Dumont, because it was a part of the scheme for testing the capacity of giving definite direction to such an apparatus that the Eiffel Tower should be included in the closed curve to be described by the aeronaut. Perhaps, however, one underestimates the part played by the Tower in this instance, for M. Emmanuel Aimé, slightly changing the well-known aphorism of Voltaire, assures us if the Tower did not exist it would be necessary to invent it for the necessities of aërostation. It seems, however, that M. Dumont prefers to pursue his experiments where he gets no assistance from the lofty structure. This tendency to stray from the subject is still more noticeable in the appendix, where we get a chapter "renfermant une notice sur les travaux exécutées par mes établissements industriels de 1867 à 1890." We have no desire to quarrel with M. Eiffel on this ground. He has carried out many great and difficult works in various parts of the world, and is to be congratulated on the success that has generally attended them. In forming our estimate of what he has accomplished for engineering science he should not be judged simply by the most popular or conspicuous example of his talent, but by the work of his whole career, which he may contemplate with complete satisfaction.

VOIGTS ELEMENTARY MECHANICS.

Elementare Mechanik als Einleitung in das Studium der theoretischen Physik. Von W. Voigt. Zweite umgearbeitete Auflage. Pp. x + 578. (Leipzig: Veit, 1901.) Price Mk. 14.

THE object of this book is to provide the student of physics with a working knowledge of theoretical mechanics. With this view the reader is introduced successively to dynamics of a particle, dynamics of rigid bodies, attractions, hydrodynamics, elasticity; in each department statics holds a subordinate position, equilibrium being treated as a particular case. The design of presenting, within the compass of a volume of moderate size, an account of the things that are fundamental in the mechanics of bodies, whether solid or fluid, rigid or deformable, is entirely laudable. It brings into prominence the essential unity of subjects which are frequently treated as independent of one another; it imposes a selection of the topics to be discussed, and thus results in the elimination of much that is artificial and conventional though sanctioned by tradition.

A critical discussion of the principles of mechanics would perhaps have been out of place in a work of this character; at any rate it is not attempted by the author. His standpoint, so far as it is indicated, would appear to be nearer to that of Thomson and Tait's "Natural Philosophy" than to that of Kirchhoff's "Vorlesungen über mathematische Physik, Mechanik." As regards methods, it is noteworthy that the author makes comparatively little use of the conception of energy, and that he does not introduce Lagrange's equations. Accordingly, the stability of floating bodies is discussed geometrically after the manner of Dupin, and the small oscillations of a system with a finite number of degrees of freedom are not discussed at all. On the other hand, space is found for an account of "vector fields" and "tensor fields." The distribution of velocity in a fluid affords an example of a vector field, the distribution of strain in a body affords an example of a tensor field; with a vector field there is associated at each point a directed linear segment, with a tensor field there is associated at each point a certain surface of the second degree. Most recent continental writings on physical mathematics treat of vector fields. The chapter devoted to the dynamics of rigid bodies is made unusually interesting by the use of the theories of several pieces of apparatus—the balance, bifilar suspension, Atwood's machine, Foucault's pendulum—as illustrations of the mode of formation and solution of equations of equilibrium or motion. The theory of the application of the pendulum to the determination of the acceleration due to gravity is also given. The treatment of rolling friction, of which two accounts, apparently conflicting with each other, are given in two separate articles, leaves something to be desired. An excellent feature of the book is the emphasis laid on the "dimensions" of physical quantities; no quantity is introduced without an explicit statement of its dimensions in terms of the units of mass, length and time.

The plan and purpose of the book require that the reader should not be assumed to possess a knowledge